LETTER TO THE EDITOR

LEST WE FORGET GENERATOR TECHNOLOGY

To the Editor: The $^{99}Mo/^{99m}Tc$ generator was introduced to nuclear medicine in the mid-1960s. In 1996, the $^{99}Mo/^{99m}Tc$ generator still is a cornerstone of diagnostic nuclear medicine, but the need for fiscal restraint dictates that both new and old technologies be re-evaluated to ensure they are being used in the most cost-effective manner. This letter is not meant to review the fundamentals of generator design and operation but rather to discuss the most effective use of this technology in the 1990s.

The concept of radioactive decay of the parent radionuclide ^{99}Mo to a daughter radionuclide (^{99m}Tc) is fundamental to generator technology. The $^{99}Mo/^{99m}Tc$ generator system is an example of a parent/daughter system that reaches transient equilibrium, at which time the ^{99m}Tc activity approximates the ^{99}Mo activity and the rate of decay of the daughter simulates that of the parent. Transient equilibrium is attained with the $^{99}Mo/^{99m}Tc$ generator system at approximately 48 hr following the last elution (Fig. 1). Transient equilibrium is not the same as when the maximum activity of ^{99m}Tc is reached. As can be seen in Figure 1, the maximum amount of activity is achieved at approximately 23 hr after the previous elution of the generator system (*1*).

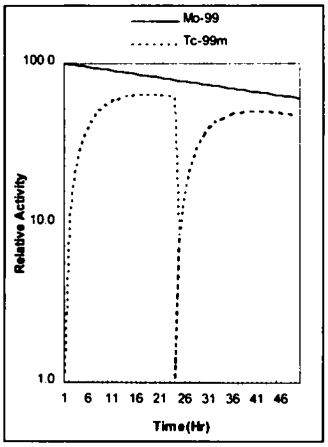

FIGURE 1. Time-activity curves for ^{99m}Tc and ^{99}Mo on a generator that is milked every 24 hr.

The activity of the daughter (^{99m}Tc) depends on:

1. Rate of formation of the daughter which is synonymous with the rate of decay of the parent.
2. Rate of decay of the daughter which is proportional to the decay constant of the daughter.
3. Time since the last elution, t. (*1,2*)

The ^{99m}Tc activity present in the generator at any given time can be calculated from the equation (*1*):

$$A_2 = (\lambda_2/\lambda_2 - \lambda_1)A_1(e^{-\lambda_1 t} - e^{-\lambda_2 t})$$

where λ_1 and λ_2 are the decay constants of the daughter and the parent radionuclides, respectively, and t is the time since the last elution of the generator. Table 1 shows that the maximum amount of ^{99m}Tc present on the generator occurs at 23 hr (actually 22.83 hr). It is this natural phenomena of maximum available ^{99m}Tc approximately every 24 hr that has

TABLE 1
Technetium-99m Activity on a 100-GBq Generator at Various In-growth Times Assuming Two Elutions per Day at the Various Intervals with the Sum of the Pertechnatate Available from Both Elutions

In-growth time (hr)	^{99m}Tc	In-growth time (hr)	^{99m}Tc activity (A2)	Sum (A1 + A2)
0.1	1.14	23.9	78.72	79.86
1	10.81	23	78.76	89.57
2	20.34	22	78.71	99.05
3	28.72	21	78.56	107.28
4	36.08	20	78.29	114.37
5	42.53	19	77.88	120.41
6	48.17	18	77.32	125.49
7	53.10	17	76.58	129.68
8	57.38	16	75.65	133.02
9	61.09	15	74.49	135.58
10	64.30	14	73.09	137.39
11	67.05	13	71.41	138.46
12	69.41	12	69.41	138.82
13	71.41	11	67.05	138.46
14	73.09	10	64.30	137.39
15	74.49	9	61.09	135.58
16	75.65	8	57.38	133.02
17	76.58	7	53.10	129.68
18	77.32	6	48.17	125.49
19	77.88	5	42.53	120.41
20	78.29	4	36.08	114.37
21	78.56	3	28.72	107.28
22	78.71	2	20.34	99.05
23	78.76	1	10.81	89.57

suited the $^{99}Mo/^{99m}Tc$ generator system to the daily needs of nuclear medicine departments around the world.

Figure 1 demonstrates that the exponential rate of buildup of ^{99m}Tc on the generator is the greatest immediately after an elution of a generator. Table 1 also shows that after just 4 hr of in-growth time the ^{99m}Tc activity has grown to approximately 34% of its maximum level. It is also significant to note that if the in-growth time between milkings of a generator is 20 hr instead of the standard 24 hr (i.e., following a second mid-day milking) the decrease in elution efficiency is only 0.5%. This scenario translates to the user being able to increase the net yield (from the standard 80%) simply by performing an additional elution of the generator during the course of the day.

The second elution of a generator with an in-growth time of 4 hr results not only in extra pertechnatate but the technetium mole fraction (fraction of technetium in metastable form) of this extra pertechnatate is approximately 70%, rather than about 27% with 24 hr in-growth time (*3*). This is important when one considers that current manufacturers' recommendations are to reconstitute certain radiopharmaceutical kits with eluate from a freshly eluted generator (*4,5*). The increased net yield of pertechnatate suffers a drawback, that of the extra pertechnatate being at a much weaker concentration, assuming that each milking uses the same standard volume of 0.9% saline. Unpublished data from this laboratory show that 96% of the ^{99m}Tc radioactivity is obtained in a volume 52% less than the standard volume used to milk the generator.

Each nuclear medicine facility is unique as defined by workload mix, volume of procedures, hours of operation, booking patterns for each type of procedure, staffing characteristics, and on call or emergency coverage, to name a few characteristics. These characteristics all contribute to the definition of a facility and thus dictate the generator requirements of that facility. Each facility, in an effort to maximize use of resources must analyze its unique operation and ensure that the $^{99}Mo/^{99m}Tc$ generator is being used to its full potential.

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